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Department of
Agriculture

Forest Service

Determining the Risk of Cumulative Watershed Effects Resulting from Multiple Activities

Endangered Species Act
Section 7

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Preface

The development of this process for assessing the relative risk of adverse cumulative effects was initiated in response to a request from the National Marine Fisheries Service (NMFS). Individual assessments of projects did not provide sufficient information for determining the cumulative effects of multiple projects within a watershed within the Snake River drainage. A consistent procedure was needed which could be used in all three Forest Service Regions to portray the risk of adverse cumulative effects.

Forest Service fish biologists and hydrologists from Regions 1, 4, and 6 met to discuss the format and content of the procedure. After the initial meeting, the procedure was drafted and sent out for review by all three Forest Service Regions, Forest industry, NMFS, and tribal representatives. The process was also sent out to selected Forests for testing. This version of the process is based on the review and critique comments which were received.

People have different expectations of assessment procedures such as this. There is no basic assumption that the procedure will satisfy everyone's needs or hopes. This process attempts to use available information and relationships to communicate levels of risk to Forest Service line officers and decision makers from other agencies. Much of content is based on professional understanding of the way natural systems respond to natural and induced conditions. As such, the process will need to be evaluated and modified as our knowledge of aquatic and terrestrial ecosystems increases.

INTRODUCTION

The Endangered Species Act of 1973 (ESA) requires consultation with the National Marine Fisheries Service (NMFS) or the US Fish and Wildlife Service (USFWS) on projects in areas containing federally listed Threatened or Endangered Species. Both informal and formal consultation can require an evaluation of the cumulative effects of the proposed actions. Under ESA, individual project biological assessments (BAS) will conclude one of four conditions from the proposed action:

- No Effect (NE),
- Beneficial Effect (BE),
- Not Likely to Adversely Affect (NLAA), or
- Likely to Adversely Affect (LAA).

The following process is designed to evaluate the potential risk of adverse cumulative effects of multiple activities within a watershed. Consultation on existing projects with the National Marine Fisheries Service under section 7 of the Endangered Species Act provided the motivation for the creation of the process. As such, it is not intended to be used as a process for evaluating cumulative effects for new project proposals.

This process is offered as a starting point. Monitoring and evaluation of the process and its implementation will be used to develop future refinements for evaluation of the risk of adverse cumulative effects.

The process was designed to use existing information rather than require additional field survey. It relies on the professional conclusions which are documented in project level BAS, an assessment and understanding of existing watershed and channel conditions which affect fish habitat, and professional judgement about the potential for a combination of all of these factors to produce adverse cumulative effects on listed salmonid species. The end product is a classification of potential risk of adverse cumulative effects rather than quantitative estimates of changes in fish habitat or watershed condition. The risk assessment allows line officers and decision makers to compare and evaluate existing conditions and possible project effects within watersheds.

The following process is one approach for identifying the risk of adverse cumulative effects to fish populations on lands administered by the Forest Service within a watershed. Cumulative effects analysis for activities outside the Forest boundary are required by both NEPA and the ESA. ESA states that "cumulative effects are those effects of future State and or private activities, not involving federal activities, that are reasonably certain to occur within the action area of the Federal action subject to consultation." NEPA states: "cumulative impact is the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-federal) or person undertakes such other actions. The Forest Service, then, needs to complete the cumulative effects analysis by acknowledging actions that could contribute to a cumulative effect in the watershed.

The Forest Service will generally have limited information about the condition of watersheds or stream systems which are off-Forest. Similarly, information about management activities on other lands which may contribute to cumulative effects may be limited. Cumulative effects assessments conducted for Forest Service activities need to describe the possible influence that off-Forest activities may have on conditions within the watershed relative to downstream conditions. In the evaluation, it is appropriate to include statements which qualify the accuracy of information available from other ownerships.

PROCESS DESCRIPTION

Overview:

Scale is always an important consideration in cumulative effects analysis. To provide the greatest amount of site specific resource information, the starting point for this analysis process is the project level. The question, then, is how big an area to use when aggregating individual project effects. While the following process could conceivably be used at very small scales, the intent is to target watersheds which are larger than 20,000 acres. The risk of adverse cumulative effects will be concluded at the watershed level following analysis of all projects in the watershed. Aggregation of watershed scale evaluations can be used for estimating risk of cumulative effects at the river basin scale (100,000 + acres).

Two levels of analysis are used to evaluate the risk of cumulative effects of the projects. The first level relies on the professional determination of individual project BAS in the watershed (e.g. NE, BE, NLAA, and LAA). The second level uses a quantitative/qualitative assessment of existing conditions, individual project ratings, and professional interpretation.

Assumptions:

This procedure is based on the following assumptions:

- Adverse cumulative effects from multiple projects can occur. The potential for them to occur and their magnitude will depend on the number, type and location of projects, watershed sensitivity, existing channel/habitat condition, and/or existing watershed condition.
- Projects which are considered to be "No Effect" and "Beneficial Effect" will not further degrade channel/habitat conditions cumulatively.
- Effects are additive or synergistic and the cumulative effect is no less than the single most adverse effect.
- At best, multiple "Not Likely's" would have a neutral cumulative effect; at worst, multiple "Not Likely's" would have an adverse effect.
- An adverse effect equates to a reduction in overall potential fish production in the basin.

- Determination of the relative risk of cumulative effects can be based on existing information and professional interpretations. New information and analytic processes can result in changes to the process in the future.

Level I Analysis

All projects within a watershed are displayed by resource area with their respective BAS conclusions arrayed. Projects with Beneficial Effect (BE) or No Effect (NE) ratings are displayed as part of the mix of projects within a watershed. If any project in the basin has a Likely to Adversely Affect (LAA) conclusion, there will be a cumulative effect to the basin, regardless of the spatial or temporal distribution of projects. Every effort should be made to modify projects which have LAA classification to remove the factors which create possibility of adverse effects. If the project can not be eliminated or modified to change the "LAA" conclusion to a "NLAA", "NE" or "BE", the only course of action is to proceed with formal consultation with NMFS.

If a "LAA" project is carried forward for formal consultation, it will need to be incorporated and analyzed with all the other activities in the watershed as part of a Level II analysis.

Level II Analysis

Substantial questions have been asked about the potential cumulative effects of multiple projects which have been individually classified as "Not Likely to Adversely Affect" (NLAA). If there are projects in the watershed which have a "NLAA" conclusion, a Level II analysis is required. This analysis deals directly with the potential for adverse cumulative effects of multiple activities which have been classified as Not Likely to Adversely Affect. It is important to remember that these projects all reside as a subset of a higher category: <u>May Affect</u>. These projects range from individual erosion control projects on lake or stream banks to salvage timber sales covering many thousands of acres. There is a range of inherent risks within the projects which have been classified as NLAA.

The combined effect of these individual projects has not been determined at a watershed level. The possible risks of not making this type of cumulative assessment are illustrated through the following analogy.

Assume that you are seated in a wing seat of an airplane and observe, over the course of a 2-3 hour flight, that there are an increasing number of rivets in the wing coming loose. When do you reach a point that you feel that the flight attendant should know? After 1 rivet? After 2? 5? Questions that you probably run through your mind in this situation may be: "How old is this plane?" "Are the rivets all located in one area or are they spread out over the wing surface?" "Are all rivets equally important to the airplane's ability to fly?" The questions address key criteria for determining the potential risk for cumulative effects.

These criteria deal with: **existing conditions** (how old is the plane and has it been well maintained?), **type of impact** (is it only rivets coming out or is it entire plates of metal?), **density**

(are all the rivets in one area?), **location** (am I more concerned about rivets next to the fuselage or along the wing surface?), and **sensitivity** (how many rivets are there to begin with?). These same criteria need to be evaluated to determine the relative degree of risk associated with numerous "not likely to affect" projects in a watershed.

Within a watershed, a Level II analysis is used to determine the **relative risk** of incurring adverse cumulative effects from actions which, individually, would be "not likely to adversely affect" fish production. This process is intended to show the relative probability of incurring additional risks to fish habitat based on existing conditions and potential project effects within a given watershed. Full consideration must be given to the spectrum of existing conditions which range from good or adequate habitat to areas where habitat or water quality are already limiting fish production.

There is no existing model which will answer all the questions about interactions and consequences of an individual project, much less groups of projects separated in space and time. The level II process is structured on professional judgement used in conjunction with available data and interpretive or analytic models. The process provides the decision maker with an assessment of the relative degree of risk of cumulative effects from multiple projects and information about the probable causes (i.e., existing conditions, projects, or a combination).

The level II process

WATERSHED CONDITION RATING

It is recognized that there is a broad range of variability with respect to inherent watershed sensitivity. Some watersheds are very sensitive due to steep slopes and highly erodible soils. Other watersheds are much more resilient and capable of accommodating extreme climatic events or higher intensities of management. One primary purpose of this process is to provide an assessment of conditions which relate to hydrologic functions within a watershed. The idea is to provide line officers and decision makers with an index of the risks of a mix of management activities on a specific landscape. If the goal were to provide a risk index for comparison of watersheds, criteria for inherent watershed sensitivity would need to be developed. Comparison between watersheds is expected but may not be very meaningful due to the range of inherent features of the watersheds. For this exercise, current watershed conditions provide an integrated index of all natural and induced events within a watershed.

The degree of management within a watershed is an index of the potential to experience adverse effects to aquatic resources. As a general rule, the probability of experiencing negative effects increases as the percentage of the watershed affected by management increases. This part of the process results in an index of current watershed condition which is based on key management indicators which influence the hydrologic functions of a landscape. There are a number of ways to describe the intensity of past management within a watershed. With the objective of using indicators of potential effects on water yield and timing as well as erosion and sediment potential, two primary upslope indicators were selected. These key indicators are road density and the percent of the watershed which is covered with "hydrologically immature" vegetation. Effects on

watershed condition created by grazing of domestic stock are discussed in the section of this document dealing with Channel Condition.

The term "hydrologic immaturity" is used to indicate forested stands in which root structure and canopy density have not reached the level of water use and influence created by mature stands. With recognition that the timeframe for reaching hydrologic maturity will vary based on site and tree species, in this exercise, hydrologic immaturity is represented by forested stands which are less than 30 years old.

Road Densities (mi/sq mi)

The effects of roads on hydrologic functions and resultant water quality are well documented in the literature (references are provided in the Bibliography). Roads influence groundwater interception, runoff distribution over time and space, and the potential for sediment production and delivery to streams. Road crossings can also influence stream temperature through the removal of shading vegetation.

There are many factors which could be evaluated to determine the risk of a road influencing water yield or water quality. These include: location, dimensions and surfacing, age, and maintenance level. Watershed slope greatly influences the potential for groundwater interception and redistribution of flows. Watershed relief is computed as the difference in elevation between the highest and lowest points of the basin divided by the length of the basin in a line roughly parallel to the major drainage (Dunne & Leopold, Water in Environmental Planning). Road density, expressed as miles of road per square mile of watershed area, is easily calculated and provides an index of the overall potential for roads to affect watershed function.

The following table places road densities into three watershed risk classes relative to overall watershed relief. The numbers were developed through interdisciplinary discussions and should be critically evaluated and may be changed based on documented research.

Road Density (mi./sq. mile)

	Watershed Relief	
	≥30%	≤30%
Low Risk	< 2	<3
Moderate Risk	2.1-3.5	3.1-4.5
Highest Risk	> 3.6	>4.6

Percent of Watershed in Stands less than 30 years:

Young stands, resulting from harvest and reforestation or natural processes (fire, disease) are indicative of the potential effects on the magnitude and timing of runoff from the watershed as the result of altered interception and soil moisture utilization. The concept of hydrologic recovery is commonly applied to assessments of watersheds and cumulative effects (Christner, 1980; Harr,

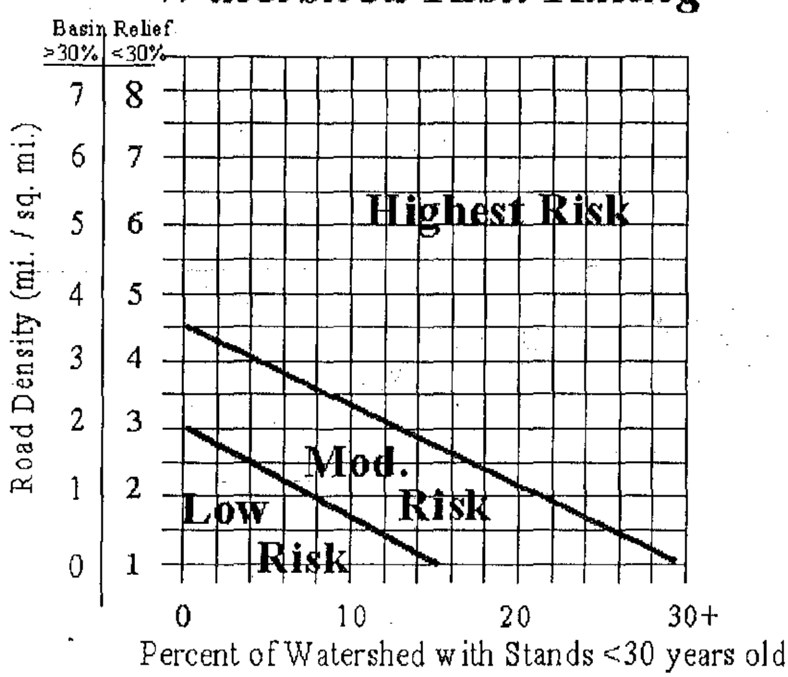
1986; Troendle et.al., 1979). The concept is the heart of the Equivalent Clearcut process used in Region 1 and the Aggregate Recovery Percentage used in Region 6. The following table, which is based on a range of values being used by professional hydrologists and fish biologists in the Northwest, presents the hydrologic recovery concept in terms of relative watershed risks. The percentage values are calculated by summing all acres which have been changed to early seral stage conditions (<30 years) due to harvest, fire, or disease and dividing the result by the total area in the watershed.

	Percent of Watershed with Forested Stands less than 30 years old
Low Risk	< 15%
Moderate Risk	15-30
High Risk	> 30%

Figure 1 is used to determine the Watershed Risk Rating based on the road density and the percentage of the watershed with forested stands which are less than 30 years old.

Figure 1

Watershed Risk Rating



CHANNEL CONDITION RATING

Channel condition, which integrates past climatic, physiographic and management influences, is an essential indicator of overall watershed condition. Significant concerns have been raised about the effects of domestic grazing on watershed and channel condition. There is little doubt that intense, uncontrolled grazing can affect the hydrologic function of an area through decreased infiltration, increased surface erosion, and direct effects on streambank instability. The greatest effects occur when grazing within riparian areas creates trampled, bare conditions. Domestic stock have a natural tendency to concentrate in riparian areas, thereby increasing the potential for damage to these highly valuable sites. Since there is a lesser chance of significant damage to upslope areas than there is to the riparian areas it is assumed that the effects of grazing will be integrated into the channel condition index.

There are many ways to index channel and fish habitat conditions. The key elements chosen to aid in the determination of potential adverse cumulative effects are tied to the *Desired Future Condition* numeric standards which are being developed for implementation of the Tri-region Anadromous Fish Policy. The intent is to allow the field biologist to select a minimum of two variables which are indicative of factors believed to be limiting fish populations in a given watershed and to use data in which they have the most confidence. The 2 key variables can be chosen from the following list:

- Primary pools (pools per mile),
- Temperature (degrees F),
- Sediment (percent surface fines, or embeddedness),
- Large woody debris (pieces per mile)

If all four variables are evaluated, the two which provide the most restrictive condition rating should be carried forward for determination of Channel Condition.

Pool frequency, expressed as pools per mile, is a key feature which can be used to describe habitat quality. A comparison of data collected within Oregon, Washington, Idaho, and Alaska provides insight to what may be considered "good" habitat based on pools per mile. For this analysis, it is assumed that "poor" habitat would be represented by pool frequencies which are one half of the "good" levels. "Fair" habitat would fall between the two extremes.

Pools per Mile

Wetted Width (feet)	Good	Fair	Poor
5	184	92-183	< 92
10	96	48-95	< 48
15	70	35-69	< 35
20	56	28-55	< 28
25	47	24-46	< 24
50	26	13-25	< 13
100	18	9-18	< 9
150	12	6-12	< 6
200	9	4-9	<4

When quantitative data about primary pools is not available, the following qualitative descriptions may be used to determine relative habitat conditions. When field data is lacking, documentation of the analysis should clearly include statements describing the process used to arrive at the conclusions and statements about the qualifications of the analyst to derive such interpretations.

- Good: Major pools are well balanced with riffle and glides throughout the stream. Individual pools are generally deeper than 18" in depth and are often greater than 36".
- Fair: Major pools are noticeably less frequent than "fast" water habitat (riffles and glides). Pools often are less than 18" in depth. Deeper pools are present but not common.
- Poor: Major pools are infrequent in the stream. Fast water habitat, particularly riffles noticeably dominate most of the stream network. Deep pools are rarely found.

Temperature (deg. F):

Water temperature controls the rates of biologic processes, is of critical concern for fish populations, and is a primary indicator of habitat and channel conditions. The following table presents a first approximation of low flow, summer-time, maximum daily water temperature thresholds for defining habitat condition classes. The values in the table are an attempt to relate to existing water quality standards for temperature. It is recognized that temperature standards are drainage specific and thresholds may vary by location. It is also recognized that temperature requirements vary between fish species. It is acceptable to modify the values in the following table as long as the changes are supported by valid local research or data and are fully documented in the analysis presentation to the decision maker.

	Water Temperature (deg. F)
Good	< 61
Fair	61-68
Poor	> 68

When temperature data is not available, the amount of stream shading can be used as a surrogate for temperature. These numbers were derived from existing Forest Plans and are useful only as general averages. Site capability and vegetative characteristics determine the feasibility of meeting these values and providing shade to a stream at any given location. Modeling has been used to test the 80% value of "Good" stream shade (Park, personal communication, 1993). For streams which are well within the State water quality standards, a 2 degree increase in temperature is permissible. On a 5,000 acre watershed, removal of 20% of stream shade along 1 mile of stream length results in a potential increase of 1-2 degrees at the watershed's mouth.

	Stream Shade (%)
Good	> 80%
Fair	60 - 79%
Poor	< 60%

Sediment

Sediment levels in streams which exceed the stream's natural sediment capacity can have significant effects on habitat for salmonids. There are many ways in which sediment can influence fish populations. These effects can be directly linked to individual fish species and life stages. There are a variety of ways to measure sediment levels relative to fisheries concerns. Two of these measurements are: (1) percent surface fines, and (2) cobble embeddedness.The following values have been derived from the literature (Phillips,1979 ;Reed,1977; Beschta et. al, 1979; Tappel et. al., 1983) and generally address spawing and rearing conditions. The tables present approximate thresholds for habitat condition classes for these two sediment measures.

Percent surface fines can be used to indicate the presence of introduced sediments and can in certain channel/habitat conditions, present tremendous risk to fish populations.

Habitat Condition	Percent surface fines
Good	< 10%
Fair	10-20%
Poor	> 20%

Habitat Condition	Cobble embeddedness
Good	<20%
Fair	20-35%
Poor	>35%

Figure 2, which is composed of a set of graphs and tables to represent the individual habitat indicators, is used to determine an overall Channel Condition Rating for the watershed.

OVERALL CONDITION RATING

Figure 3 combines the watershed rating from Figure 1 and the channel rating from Figure 2 to obtain an Overall Condition Rating for the watershed. This rating is used as one of the major criteria for determining the risk of adverse cumulative effects to fish populations. The second major criteria is the level of project risk.

INDIVIDUAL PROJECT RISK ASSESSMENT

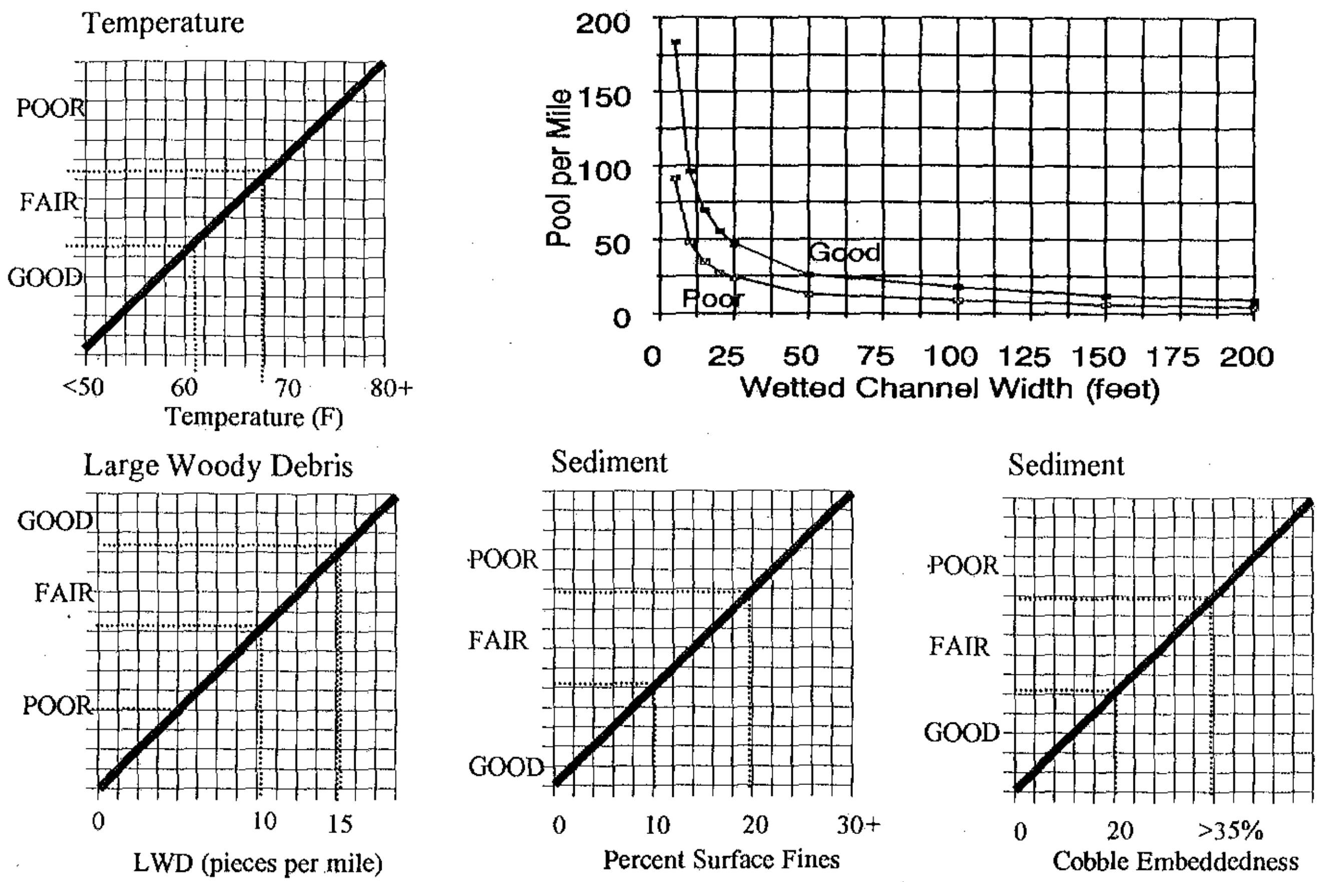
There is a wide range of potential risk to aquatic ecosystems associated with the Not Likely to Adversely Affect projects. Every project or activity within a watershed is to be evaluated. It is recognized that some activities, such as mining, have potentially devastating effects on water quality. The risk of these types of activities depends on existing controls for point source pollution. The biologist responsible for evaluating the effects of individual projects will need to have an awareness of the site specific conditions and situation for these types of projects.

When projects along steep, constrained channels will remove tree boles from a zone which is one tree height in width (from both sides of a channel) the potential for depriving large woody debris exists. This is a concern both from the need for onsite channel complexity as well as for downstream recruitment of woody debris. Based on the magnitude of proposed removal, a project can pose a "High risk" in terms of Large Woody Debris recruitment potential. If there is a risk of depriving large woody debris to systems which are not meeting desired conditions the effects should be documented as being High Risk.

Nonpoint sources of pollutants generally are associated with sediment production or temperature changes. Each project in a watershed will be evaluated for its influence on sediment and temperature. Tabulate each project within a watershed and the acres that the project affects. Use "Risk of Temperature Effects" (Figure 4) for all projects within 200 feet of a stream channel and "Risk of Sediment Effects" (Figure 5) for all projects within the watershed. Note that both processes can/will be applied to the same project.

At the end of the flowchart process for temperature and sediment, a determination of Low, Medium or High risk will be produced for each project. This relative risk rating should be tabulated for each project. Once all the projects have been tabulated, sum all the acres of projects having High or Moderate ratings for large woody debris, temperature, or sediment. Calculate the percentage of the total watershed area which contains High or Moderate risk projects.

Figure 2. *Channel Condition Rating*



Channel Condition Rating

Rating for Element 2 above	Rating for Element 1 above: POOR	FAIR	GOOD
POOR	POOR	POOR	POOR
FAIR	POOR	FAIR	FAIR
GOOD	POOR	FAIR	GOOD

Figure 3. *Overall Condition Rating*

Habitat Rating	Watershed Risk Rating: High	Moderate	Low
Poor	Poor	Poor	Poor
Fair	Poor	Fair	Fair
Good	Poor	Fair	Good

Figure 4.
Project Risk of Temperature Effects

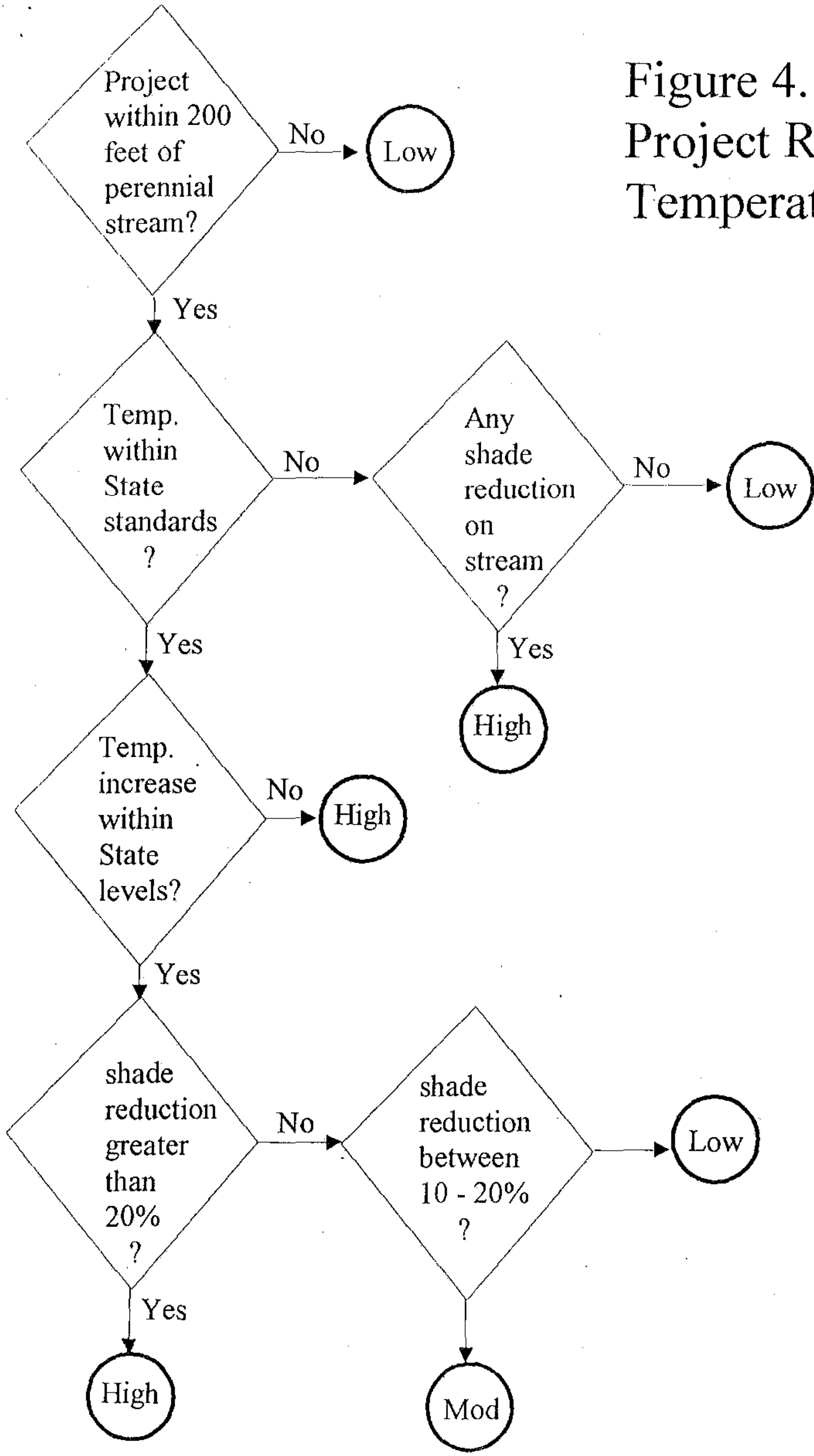


Figure 5. Risk of Sedimentation

The following table (USDA Forest Sevice, Region 1, WATSED, 1991) should be used to estimate the probability of sediment delivery to stream channels for all projects which will create or maintain loose, unprotected surface soils. For projects which occur over large areas and on many landforms, the highest risk for any of the landforms should be used. Projects which have any probability of influencing or increasing the risk of mass erosion should be rated as having a HIGH risk for sedimentation of streams.

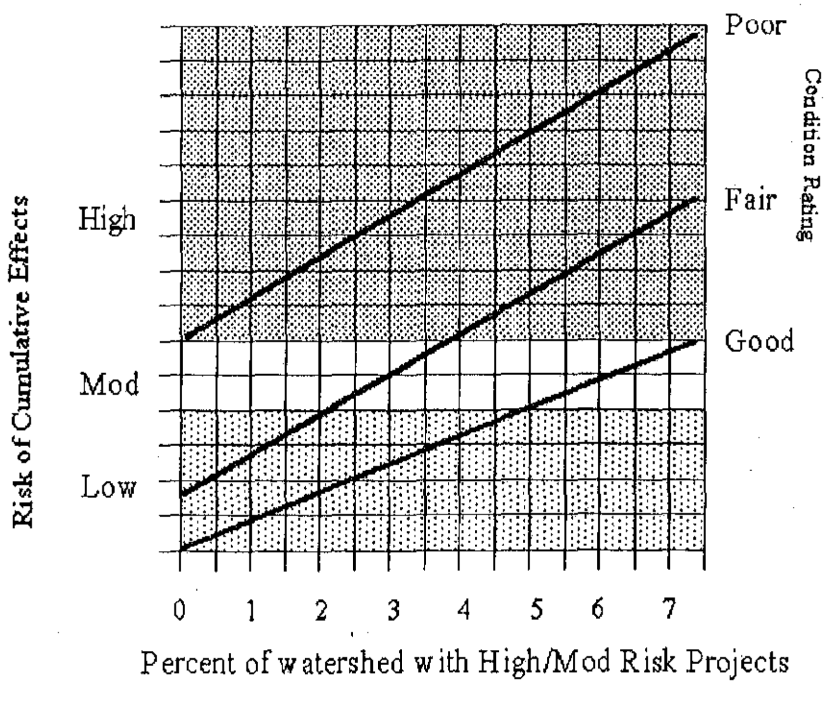
	Slope Position				
Dominant Landform	Ridge	Upper	Middle	Lower	Streamside
Glaciated Mountain Ridge-tops	Low	Low			
Glaciated Mountain Slopes		Low	Mod	Mod	Mod
Cirque Basins			Low	Low	Low
Cirque Headwalls	Low	Low	Low	Low	Low
Mountain Slope - Disssected		Mod	High	High	
Mountain Slope	Low	Low	Low	Mod	Mod
Stream Bottoms				Mod	High
Stream Terraces				Low	Low
Alluvial Fans				Low	Low
Stream Breaklands	High	High	High	High	High

RISK OF ADVERSE CUMULATIVE EFFECTS

Given the above information, a High, Medium or Low risk of cumulative effect can be determined for the watershed. Figure 6 contains 3 bands depicting the relative risk of cumulative watershed effects. The 3 bold lines on the chart represent the Overall Condition rating derived from Figure 3. To use the graph, locate the percentage of the watershed which has High or Moderate risk projects on the x-axis. Extend a line vertically upward to intersect the line reflecting the appropriate Overall Condition Rating for the watershed. From this point, move horizontally to determine the relative risk of adverse cumulative effects.

In Figure 6, the values for the percentage of the watershed having High or Moderate risk projects are first approximations developed by professional hydrologists and fish biologists. Field testing of the relationships in Figure 6 has produced results which are consistent with professional understanding and belief. As experience is gained with the process, the values in Figure 6 may need to be adjusted.

Figure 6. Risk of Cumulative Effects



GLOSSARY

Road Density - the concentration of roads, expressed as miles of road per square mile of watershed area. Roads should include all system roads and temporary roads which have not been restored to natural hydrologic conditions.

Watershed Relief - the average watershed slope determined as the difference between the lowest and highest points in the watershed divided by the length of a straight line projected along the main axis of the watershed and roughly parallel to the main drainage.

Pools - a channel morphological unit that has a wetted length greater than wetted width, a hydraulic control spanning the full channel, and a defined scour somewhere within the wetted area. Generally, the scour is greater than 1 foot deep.

Temperature - Stream temperature determined by field measurement. Units should be degrees Fahrenheit to maintain consistency with State standards terminology.

Shade - Shade is the product of interception of direct insolation by vegetation or topography. The projection of diffuse sunlight past and through intercepting material onto the surface of a streamcourse.

Sediment - Generally, inorganic material which has been eroded from upslope sources and transported by water or gravity to a deposition area. While erosion and sedimentation occurring on upslope areas can influence site productivity, the primary concern in this analysis is sediment delivery to streams.

Large Woody Debris - Organic material which is greater than 6 inches at the smalles diameter and greater than 20 feet in length. It can be either standing or lying within the active channel.

Active Channel Width - the straight line distance across a stream channel that is perpendicular to the stream banks. It is measured at a level which is coincident with that level at which bankfull discharge would leave the channel and spill onto the floodplain.

Watershed - a region or area which drains to a particular water course or body of water. Generally referred to based on surface drainage rather than groundwater drainage.

Riverbasin - an area which is composed of several watersheds. Riverbasins are generally in excess of 100,000 acres in size.

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